CLAIMS

1. Apparatus for making a glass preform by flame hydrolysis, comprising:

housing that defines a deposition chamber;

support mandrel mounted within the deposition chamber, for rotation about a longitudinal axis; and

main deposition burner having a central axis oriented substantially orthogonal to the support mandrel's longitudinal axis and configured to direct two or more streams of soot-forming reactants and a stream of flame gases toward the support mandrel, so as to form by flame hydrolysis a glass preform on the mandrel, wherein the burner includes a pair of divergent reactant ports for producing two of the streams of soot-forming reactants, such divergent reactant ports located on opposite sides of the burner's central axis and defining axes that diverge from the burner's central axis, such that the two streams of soot-forming reactants impinge substantially quasi-tangentially on the glass preform, on opposite sides of the longitudinal axis, to reduce turbulence in the streams at the site of the preform.

2. Apparatus as defined in claim 1, and further comprising:

one or more auxiliary burners configured to introduce one or more streams of flame gases, but no stream of soot-forming reactants, toward the glass preform, to heat portions of the preform not fully heated by the stream of flame gases directed by the main deposition burner; and

a controller configured to controllably operate the one or more auxiliary burners after the glass preform formed on the support mandrel has reached a predetermined size.

3. Apparatus as defined in claim 2, wherein the apparatus comprises one or more pairs of auxiliary burners, located on opposite sides of the main deposition burner and spaced circumferentially around the support mandrel.

4. Apparatus as defined in claim 1, and further comprising a mount configured to withdraw the main deposition burner from the glass preform as the preform grows in size, to reduce turbulence in the one or more streams of soot-forming reactants at the site of the preform.

5. Apparatus as defined in claim 1, wherein the main deposition burner comprises:

a central reactant port, aligned with the burner's central axis, between the two divergent reactant ports, for producing a central stream of soot-forming reactants; and

a plurality of flame ports, arranged concentrically around the central reactant port and around the two divergent reactant ports, for forming the flame concentrically around the streams of soot-forming reactants.

6. Apparatus as defined in claim 5, wherein the main deposition burner further comprises a first plurality of shield gas ports, arranged concentrically around the central reactant port and around the two divergent reactant ports, between the reactant ports and the plurality of flame ports, for forming an inner shield gas stream between the streams of soot-forming reactants and the flame.

7. Apparatus as defined in claim 6, wherein the main deposition burner further comprises a second plurality of shield gas ports, arranged concentrically around the central reactant port, radially outward of the plurality of flame ports, for forming an outer shield gas stream radially outward of the flame.

8. Apparatus as defined in claim 5, wherein the plurality of flame ports are configured to direct the flame obliquely inwardly toward the main deposition burner's central axis.

9. Apparatus as defined in claim 8, wherein the plurality of flame ports are asymmetrically configured, such that the flame is oriented

obliquely inwardly toward the main deposition burner's central axis along one transverse axis, but is oriented substantially parallel with such central axis along an orthogonal transverse axis.

10. Apparatus as defined in claim 5, and further comprising a valve that controls the delivery of reactant gases to the central reactant port and to the pair of divergent reactant ports according to the size of the glass preform being formed on the support mandrel.

11. Apparatus as defined in claim 1, wherein the main deposition burner is configured to burn a mixture of oxygen and natural gas.

12. Apparatus as defined in claim 1, wherein the main deposition burner is configured to burn a mixture of oxygen and hydrogen.

13. Apparatus for making a glass preform by flame hydrolysis, comprising:

a housing that defines a deposition chamber;

a support mandrel mounted within the deposition chamber, for rotation about a longitudinal axis;

a main deposition burner configured to direct one or more streams of soot-forming reactants and one or more streams of flame gases toward the support mandrel, so as to form by flame hydrolysis a glass preform on the mandrel;

one or more auxiliary burners configured to introduce one or more streams of flame gases, but no stream of soot-forming reactants, toward the glass preform, to heat portions of the preform not fully heated by the stream of flame gases directed by the main deposition burner; and

a controller configured to controllably operate the one or more auxiliary burners after the glass preform formed on the support mandrel has reached a predetermined size.

14. Apparatus as defined in claim 13, wherein the main

deposition burner is configured to direct one or more streams of soot-forming reactants substantially quasi-tangentially toward the glass preform being formed on the support mandrel, to reduce turbulence in the streams at the site of the preform.

15. A deposition burner suitable for use in an apparatus for making a glass preform by flame hydrolysis, comprising:

a central reactant port that forms a central stream of soot-forming reactants that follows a central axis;

a pair of supplemental reactant ports located on opposite sides of the central reactant port, for forming supplemental streams of soot-forming reactants, wherein the supplemental reactant ports define axes that diverge from the central axis of the central reactant port, such that the supplemental streams exit the supplemental reactant ports along paths that diverge from the central axis; and

a plurality of flame ports, arranged concentrically around the central reactant port, and around the supplemental reactant ports, for forming a flame around the streams of soot-forming reactants.

16. A deposition burner as defined in claim 15, and further comprising a first plurality of shield gas ports, arranged concentrically around the central reactant port and around the supplemental reactant ports, between the reactant ports and the plurality of flame ports, for forming an inner shield gas stream between the streams of soot-forming reactants and the flame.

17. A deposition burner as defined in claim 16, and further comprising a second plurality of shield gas ports, arranged concentrically around the central reactant port and around the supplemental reactant ports, radially outward of the plurality of flame ports, for forming an outer shield gas stream radially outward of the flame.

18. A deposition burner as defined in claim 15, wherein the plurality of flame ports are oriented and configured to direct the flame obliquely

inwardly toward the central axis.

19. A deposition burner as defined in claim 15, wherein the plurality of flame ports are asymmetrically configured, such that the flame is oriented obliquely inwardly toward the main deposition burner's central axis along one transverse axis, but is oriented substantially parallel with such central axis along an orthogonal transverse axis.

20. A deposition burner as defined in claim 15, and further comprising a valve that controls the delivery of reactants to the central reactant port and to the pair of supplemental reactant ports according to the size of the glass preform being formed.

21. A deposition burner as defined in claim 15, wherein the burner is configured to burn a mixture of oxygen and natural gas.

22. A deposition burner as defined in claim 15, wherein the burner is configured to burn a mixture of oxygen and hydrogen.

23. Apparatus as defined in claim 5, and further comprising means for supplying reactant gases to the central reactant port and to the two divergent reactant ports and for supplying flame gases to the plurality of flame ports.

24. Apparatus as defined in claim 13, and further comprising means for supplying reactant gases and flame gases to the main deposition burner and for supplying flame gases to the auxiliary burners.

25. A deposition burner as defined in claim 15, and further comprising means for supplying reactant gases to the central reactant port and to the pair of supplemental reactant ports and for supplying flame gases to the plurality of flame ports.

26. A method for making a glass preform by flame hydrolysis, comprising:

providing a deposition apparatus that includes

a housing defining a deposition chamber,

a support mandrel mounted within the deposition chamber, for rotation about a longitudinal axis, and

a main deposition burner having a central axis oriented substantially orthogonal to the support mandrel's longitudinal axis and including a pair of divergent reactant ports that are located on opposite sides of the burner's central axis and that define axes that diverge from the burner's central axis; and

supplying chemicals to the burner while the support mandrel is rotated about its longitudinal axis, such that the pair of divergent reactant ports of the burner emit two streams of soot-forming reactants toward the support mandrel and such that the burner further emits a stream of flame gases toward the support mandrel, so as to form by flame hydrolysis a glass preform on the mandrel, wherein the two soot-forming streams impinge substantially quasi-tangentially on the glass preform, on opposite sides of the longitudinal axis, to reduce turbulence in the streams at the site of the preform.

27. A method as defined in claim 26, wherein:

the step of providing a deposition apparatus further includes providing one or more auxiliary burners configured to direct one or more streams of flame gases, but no stream of soot-forming reactants, toward the glass preform; and

the method further comprises controllably operating the one or more auxiliary burners after the glass preform formed on the support mandrel has reached a predetermined size, to heat portions of the preform not fully heated by the stream of flame gases directed by the main deposition burner.

28. A method as defined in claim 27, wherein the one or more auxiliary burners provided in the step of providing include one or more pairs of

auxiliary burners located on opposite sides of the main deposition burner and spaced circumferentially around the support mandrel.

29. A method as defined in claim 26, and further comprising withdrawing the main deposition burner from the glass preform as the preform grows in size, to reduce turbulence in the one or more streams of soot-forming reactants at the site of the preform.

30. A method as defined in claim 26, wherein the step of providing a deposition apparatus further includes:

providing the main deposition burner with a central reactant port, aligned with the burner's central axis, between the pair of divergent reactant ports, for producing a central stream of soot-forming reactants; and

providing a plurality of flame ports, arranged concentrically around the central reactant port and around the two divergent reactant ports, for forming the flame concentrically around the streams of soot-forming reactants.

31. A method as defined in claim 30, and further comprising controlling the delivery of reactant gases to the central reactant port and to the pair of divergent reactant ports according to the size of the glass preform being formed on the support mandrel.